KNOPF

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DEPARTMENT OF THE INTERIOR
UNITED STATES GEOLOGICAL SURVEY
GEORGE OTIS SMITH, DIRECTOR

BULLETIN 620—D

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BY

ADOLPH KNOPF

Contributions to economic geology, 1915, Part I
(Pages 59-68)

Published September 14, 1915

WASHINGTON
GOVERNMENT PRINTING OFFICE
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NOTE.—Beginning with the present volume the year included in the title of the Survey's annual "Contributions to economic geology" will be the year of publication instead of the year in which the field work reported was done. This volume is therefore dated 1915, and there will be no volume entitled "Contributions to economic geology, 1914." The volume will be issued in parts, as heretofore, and the last part will include a volume title-page, table of contents, and index for the use of those who may wish to bind the separate parts. A small edition of the bound volume will also be issued, but copies can not be supplied to those who have received all the parts.

SOME CINNABAR DEPOSITS IN WESTERN NEVADA.

By Adolph Knopf.

DEPOSITS EAST OF MINA.

LOCATION AND HISTORY OF DISCOVERY.

A belt of cinnabar deposits is situated in the heart of the Pilot Mountains, in an air line 8 miles south of east of Mina, Esmeralda County, Nev. The average elevation above sea level here is 7,300 feet, or about 2,700 feet above Mina, the local supply point, which is on the Southern Pacific system. The deposits are accessible from Mina by a good wagon road of easy grade about 12 miles long. The area in which the quicksilver deposits occur supports sufficient forest growth to furnish wood for local use as fuel and contains a number of springs that are capable of furnishing an ample domestic supply of water. The topographic features of the district and its approaches are shown on the scale of 1:250,000, or approximately 4 miles to the inch, on the United States Geological Survey's map of the Tonopah quadrangle.

The discovery that drew attention to the cinnabar of Pilot Mountains was made in June, 1913. On the day of the discovery Thomas Pepper and Charles Keough had been tracking two stray steers, when near nightfall the trail led over an old prospect in which a face of limestone traversed by small veinlets of red mineral was exposed. The red mineral was recognized by Keough as cinnabar. After finding the steers and taking them to Mina the two discoverers returned to Cinnabar Mountain, as the hill on which they had made the find has since been named, where they spent 10 days in careful search and located 17 claims. On June 18 they went back to Mina and made known their find, causing an intense excitement, and that afternoon almost every citizen of the town left for the site of the discovery by automobile and by other less expeditious conveyances. A large number of claims were staked by the first comers and many more were afterward staked by claimants from Tonopah. Unfortunately the amount of exploratory and development work has not been proportional to this early enthusiasm.

The discovery was widely heralded as the rediscovery of the "lost Hawthorne quicksilver mine," named for Judge Hawthorne, in whose

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honor it is said Hawthorne, the seat of Mineral County, is named. According to local report Judge Hawthorne discovered in the seventies a rich quicksilver deposit, which is believed to have been situated at the site of the recent discoveries. In returning from the mountains, so it is said, Hawthorne lost his bearings, and although he attempted annually to the end of his life to find the "quicksilver mine" he remained unsuccessful. This tradition seems highly improbable. The original discoverer—who he was is unknown—had done some very substantial exploratory work on the prospect. In his efforts to prove his find he had blasted out a considerable mass of solid limestone, and as further tokens of his activity sticks of powder, fuse, and picks lays abandoned at the prospect. That this energetic prospector lost his way and was unable to find the prospect at which he had labored is not easily credible. It is more likely that he abandoned the prospect as, in his judgment, not sufficiently valuable.

The newcomers have found considerably richer deposits than the unknown pioneer did, and have shown that the cinnabar extends along a considerable belt.

GENERAL GEOLOGIC FEATURES.

Cinnabar has been found at a number of places along a belt that is about 2 miles long and trends northeastward. The main area comprises the hill known as Cinnabar Mountain. Limestones make up the bulk of this hill, although some dolomitic graywacke, composed of angular and rounded quartz grains and of angular chert particles embedded in a cement of dolomite, is interstratified with them. The strike ranges from north to northeast, and the dip from 40° to 70° NW. The limestones carry crinoid fragments and other obscure fossils, and are probably of Paleozoic age. North of Cinnabar Mountain graywacke, slate, and chert form the country rock. No igneous rocks, in either dikes or flows, have been found near the mineral deposits. Tertiary lavas appear on the north flank of the mountains, but they are 4 or 5 miles from the cinnabar belt.

The cinnabar deposits on Cinnabar Mountain occur in fracture zones in limestone. The limestone is traversed by thin veinlets of white spar, and the cinnabar is intergrown with the calcite or dolomite of the veinlets or occurs as a replacement of the adjoining wall rock. The intimate penetration of the cinnabar into the body of the limestone is locally a notable feature. Stibnite is associated with the cinnabar at one locality only; pyrite and marcasite, characteristic associates of quicksilver ores the world over, do not occur in the district.

The geologic features of the quicksilver deposits north of Cinnabar Mountain are somewhat different. At the Cinnabar King prospect

the ore consists of cinnabar in a gangue of barite and the deposit is inclosed in a country rock of brecciated chert. Farther north, at the Red Devil prospect, the country rock is graywacke and the cinnabar is disseminated through a siliceous gangue.

Although highly encouraging showings of cinnabar ore have been uncovered at a number of places in the district, the amount of prospecting so far done is insufficient to prove that the linear extent of any deposit, let alone its persistence in depth, is great enough to indicate its commercial importance. The geologic features of the deposits appear to be favorable to persistence of the ore in depth of the grade and character of that at the outcrop, for the mineralization is obviously of a kind in which the deposition of the cinnabar was not dependent on immediate proximity to the surface, as it is, for example, in quicksilver deposits that are formed at the vents of hot springs.

The prospects at which the most exploratory work has been undertaken will now be described.

FEATURES OF THE PROSPECTS.

Lost Steers group.—The Lost Steers group consists of 11 claims owned by Thomas Pepper and Charles Keough. The most development work so far accomplished in the district has been done on the claims of this group. At the lowest workings a tunnel about 75 feet long has been driven, but its course is such that it fails to undercut the ore exposed at the surface.

A zone several hundred yards long, extending from the mouth of the tunnel on the north to the open cut made on the summit of the mountain by the pioneer prospector, carries cinnabar at intervals. The geologic features are essentially similar at the different exposures. The country rock is a fine-grained dark limestone, which is cut by veinlets of white spar and is sporadically impregnated with crystallized cinnabar. Locally the cinnabar without any associated gangue mineral replaces the limestone, and such occurrences constitute a very high grade of ore. At one locality some bunches of stibnite have been found, but elsewhere cinnabar is the only sulphide mineral in the deposits. At the different occurrences of cinnabar along the zone there is evidence that fracturing of the limestone was of importance in the genesis of the ore. For example, at the shaft, which is about 6 feet deep, two fairly well defined walls, 52 inches apart, can be seen. They trend N. 40° W., and the footwall, which is the better defined of the two, dips 70° SW.

The cinnabar shown in the open cut on the Lost Steers claim No. 1 occurs in a different fracture system from the one just described. The deposit on this claim lies on the east side of the summit of Cinnabar Mountain. The limestone country rock strikes north and dips

40° W. An excellently defined wall, striking north 45° W. and dipping 70° NE., forms the footwall of the deposit. The limestone lying upon this wall is reticulated with sparry veinlets of calcite carrying cinnabar, which occurs locally in considerable masses characterized by splendent cleavage faces. The system of cinnabar-bearing calcite veinlets extends at least 6 feet from the footwall. Rarely streaks of ore make out into the footwall zone.

Keg and Barrel prospect.—An open cut at this prospect shows a well-defined wall striking N. 30° E. and dipping 70° W. The country rock—a fine-grained dark dolomite—under this wall is netted with white veinlets of dolomite averaging a fourth of an inch in thickness. Coarsely crystallized cinnabar occurs in the veinlets to some extent, but mainly as a replacement of the adjoining country rock.

Cinnabar King prospect.—The Cinnabar King prospect is a short distance north of Cinnabar Mountain. The exploration work so far done consists of a small pit, which affords but inadequate information as to the nature and extent of the occurrence of the ore. This exposes the face of a body of ore, about 4 feet thick, dipping 20° N., as far as can be determined by the small developments. The ore consists of barite carrying disseminated cinnabar and averages perhaps 4 per cent of quicksilver. The general country rock, unlike that of Cinnabar Mountain, is a highly fractured chert.

Red Devil prospect.—This prospect, owned by A. C. Roach, Eugene Grutt, and A. Drew, is about 1½ miles north of Cinnabar Mountain. A shallow open cut discloses a body of good grade ore, 30 inches thick, apparently dipping at a low angle to the west. The ore consists of ocherous cinnabar in a fine-grained siliceous gangue. The country rock is a coarse graywacke made up largely of flat angular fragments of black slate.

DEPOSITS EAST OF BEATTY.

SITUATION AND DISCOVERY.

A number of quicksilver deposits are situated 6 miles east of Beatty, Nye County, Nev., the junction of the Tonopah & Tidewater and the Las Vegas & Tonopah railroads. The quicksilver-bearing area lies in the Fluorine mining district. The prospects fall into two groups, one on the east slope of Bare Mountain and the other on the northern end of Yucca Mountain, 3 miles northeast. Locally the part of the Bare Mountain group of hills on which the quicksilver prospects occur is known as Meiklejohn Mountain. The area is readily accessible by roads of easy grade. The topographic features of the area are shown on a scale of 1:250,000 on the United States Geological Survey's map of the Furnace Creek quadrangle.

At the time of the principal activity at Rhyolite, in the years immediately following 1905, prospectors spread out into the neighboring territory. The east flank of Bare Mountain was the scene of considerable activity in the search for gold, and on the Grochon claim high-grade gold ore, said to carry tellurides, was found. This ore occurs in a small irregular vein of fine-grained quartz showing no metalliferous constituents, but the lowest assays are reported to have run as high as $84 a ton in gold. This created much excitement at the time, and the camp that sprang up here was named "Telluride." Quicksilver ore was discovered in place on the east flank of Bare Mountain by J. B. Kiernan and A. A. Turner in 1908, although indications of cinnabar had been found somewhat earlier. Attention having thus been drawn to the occurrence of quicksilver, it was soon shown to have a considerably wider distribution. In 1912 a 10-ton Scott furnace was built in Gold Gulch by the Telluride Consolidated Quicksilver Mining Corporation. It is on the northeast slope of "Financier Hill," as it is locally known, one of the low hills at the northern end of Yucca Mountain, where this range merges into the hills of the Bare Mountain group. A tunnel some 1,100 feet long, starting near the furnace, was driven under this hill, which, it is said, was thought to contain $22,000,000 worth of ore, but no ore was found. The company then leased a number of properties on Meiklejohn Mountain and operated them, hauling the ore by teams to the furnace, a distance of 4 miles. In August, 1914, the company became involved in financial difficulties, its property was attached, and all work was suspended. At other places in the district a small amount of prospecting was in progress during 1914.

GENERAL GEOLOGIC FEATURES.[1]

The general country rock of the quicksilver-bearing area on the east slope of Bare Mountain is a fine-grained gray dolomite. It is rather massively bedded and has undergone considerable disturbance, so that its stratification is not readily discernible, but south of Telluride camp the beds dip 20° N. The age of the rocks, as determined from fossils embedded in a block of dolomite kindly sent to the Geological Survey by Mr. A. A. Turner, is Silurian. Dr. Edwin Kirk reports that the fossils include the species named below:

Thecia major.
Coenites verticillata.
Favosites cristatus.
Syringopora sp.
Conchidium (2 species).
Pisocrinus sp.

[1] The broader features of the geology and their relation to those of the surrounding territory have been discussed by S. H. Ball in A geologic reconnaissance in southwestern Nevada and eastern California: U. S. Geol. Survey Bull. 308, 1907.

Dr. Kirk adds:

This collection is of considerable interest, as it fixes rather definitely the age of the widespread Silurian fauna of the Western States. The beds correlate approximately with the Fusselman limestone of the El Paso region and the Laketown dolomite of Utah. On the evidence of the fossils in the present lot it is safe to place the fauna near the top of the Niagaran.

At the base of Bare Mountain a narrow belt of quartzite appears between the dolomite and the upper edge of the piedmont alluvial slope.

The rocks are cut by a number of porphyry dikes. Large phenocrysts of quartz are prominent constituents of the rock of these dikes. In fact, after the dike rock has become scarcely recognizable from decomposition, as it commonly does, only the quartz crystals are distinguishable and serve to reveal the identity of the altered rock. Feldspar and biotite also appear among the phenocrysts. Examination under the microscope of some of the better preserved material from the Columbia dike—which, however, has been altered by the development of pyrite, dolomite, and chlorite—suggests that it is a quartz diorite porphyry. The dikes are possibly related in origin to the igneous masses represented by the pegmatites that are common in the northern part of the range.[1]

The quicksilver-bearing area north of Meiklejohn Mountain is underlain by a gently dipping succession of rhyolite flows and tuffs. They are part of the rhyolite series exposed in the Bullfrog district, where they attain a thickness of more than 6,000 feet.[2] They are thought by Ball to be of early Miocene age.

The quicksilver deposits inclosed in the dolomite consist of masses of opal or of cryptocrystalline silica carrying cinnabar; those inclosed in the rhyolites consist of masses of opal and alunite carrying cinnabar. The deposits contain no other metallic sulphides, such as pyrite, marcasite, or stibnite, which are generally associated with quicksilver ores. The gangue commonly contains large bodies, in places as much as 10 feet thick, consisting of a soft white substance, which, as shown by an analysis made by R. K. Bailey in the laboratory of the Geological Survey, is a nearly pure hydrated silica, namely, silica, 90.46 per cent; water (loss on ignition), 5.38 per cent. This substance is accordingly a pulverulent variety of opal. Although opal of the hard, massive kind is the predominant gangue mineral of the deposits, various forms of cryptocrystalline silica, comprising chalcedony and exceedingly fine grained quartz also occur. Locally all three of these forms of silica are intimately associated in the same deposit. The only departure from the prevailing

[1] Ball, S. H., op. cit., pp. 155–156.

[2] Ransome, F. L., Emmons, W. H., and Garrey, G. H., Geology and ore deposits of the Bullfrog district, Nevada: U. S. Geol. Survey Bull. 407, p. 31, 1910.

simple mineralogy of the district is that shown by the deposit cut in the Banner tunnel. This consists of a chimney, a few feet in diameter, of shattered dolomite cemented by coarsely crystalline calcite and barite and carrying a small amount of cinnabar.

The quicksilver ore occurs in irregular, erratic shoots in the siliceous masses. In the dolomite the bodies of opal and cryptocrystalline silica are commonly small and are erratically distributed; in the rhyolite, however, the opalized belts extend for a thousand feet or more and attain widths of as much as 200 feet. In the opalized rhyolite the quartz phenocrysts only have remained intact; the sanidine phenocrysts have been transformed largely into alunite, the hydrous sulphate of aluminum and potassium, and the rest of the rock has been converted into opal, or into pulverulent hydrated silica, with which is associated a notable amount of alunite. The opalized condition of the rhyolites is readily recognizable by the unaided eye, but the presence of the alunite becomes manifest only under the microscope. The optical determination of the alunite was verified chemically by its sulphate reaction. In spite of the profound alteration of the rhyolite, it retains with remarkable distinctness the normal appearance of an igneous rock.

This occurrence of alunite with cinnabar is of scientific interest, for this mineral has not heretofore been recorded in association with quicksilver ores. It has, however, been described as occurring in considerable quantity in the sulphur deposits resulting from the solfataric alteration of rhyolite tuffs at Rabbit Hole Springs, Nev., and these deposits contain traces of cinnabar.[1] At Goldfield, which is 65 miles northwest of the quicksilver deposits near Beatty, alunite is an abundant constituent of the gold ores. A quicksilver deposit occurs at Goldfield; but, singularly enough, this deposit, believed by Ransome[2] to be a result of the same mineralization that produced the gold lodes, or one closely preceding or following it, does not contain alunite, the mineral so characteristic of the district.

The cinnabar in the deposits east of Beatty is not present in quantities proportional to the amount of opalization and alunization, however, but occurs sporadically throughout the belts of altered rhyolite. A more thorough prospecting of these belts than has yet been attempted appears advisable.

FEATURES OF THE PROSPECTS.

Cinnabar prospect.—The Cinnabar prospect, owned by the Denver-Bullfrog Mining Co., is on the southeast side of Meiklejohn Moun-

[1] Adams, G. I., The Rabbit Hole sulphur mines, near Humboldt House, Nevada: U. S. Geol. Survey Bull. 225, pp. 499–500, 1904.

[2] Ransome, F. L., Geology and ore deposits of Goldfield, Nevada: U. S. Geol. Survey Prof. Paper 66, pp. 113, 174, 1909.

tain. The principal development work is a tunnel 200 feet long, which intersects the cinnabar deposit at a depth of 100 feet. From the portal of the tunnel a gravity tram extends to the base of the mountain, 600 feet below. A D retort, with a capacity of 800 pounds in 12 hours, has been installed on the property, and some flasks of quicksilver have been produced. The ore body has been worked mainly, however, under lease to the Telluride Consolidated Quicksilver Corporation, which hauled the ore to their furnace on Gold Gulch.

The country rock inclosing the ore body is a hard, fine-grained arenaceous dolomite. At the outcrop the cinnabar-bearing deposit has a length of about 125 feet; in the tunnel below, about 70 feet. Opal is the principal gangue mineral. A great mass of opal, generally milk-white in color and more or less porous and cavernous in structure, is exposed in the tunnel. In this opal there are large pockets filled with soft, white hydrated silica, an analysis of which is given on page 64. Some of these masses of silica are 6 to 10 feet thick. Chalcedony forms an insignificant proportion of the opal mass. Locally the opal containing cinnabar is of gem quality, and some of this material has been polished and placed on the market.

The cinnabar is either inclosed in the opal as massive mineral or is so very finely disseminated through the opal as to give it a blood-red color. Some of the high-grade cinnabar ore, as determined under the microscope, proves to be a replacement of arenaceous dolomite. Some of the replaced rock, in fact, contains sufficient detrital quartz to be a dolomitic sandstone. The quartz grains, many of which are perfectly rounded, have remained intact, but the dolomite cement in which they were embedded has been replaced by chalcedony, opal, and cinnabar. Only rarely has a little quartz been deposited in optical continuity with the detrital quartz grains.

Early Bird prospect.—The Early Bird prospect, which is owned by the Telluride Consolidated Quicksilver Mining Corporation, is on the north flank of Meiklejohn Mountain, near its base. A large reef of cryptocrystalline silica projects prominently above the inclosing limestone; it is several hundred feet long and at its maximum is over 100 feet wide. It contained a short, narrow shoot of high-grade cinnabar ore, which has been largely removed through an adit cutting the reef at a shallow depth.

Mammoth group.—The claims of the Mammoth group (Nos. 1, 2, and 3), owned by the Telluride Consolidated Quicksilver Mining Corporation, extend along a belt of opalized and alunitized rhyolite trending N. 30° W. At its south end this belt is several hundred feet wide. The main work has been done on Mammoth No. 2, where a tunnel 50 feet long was driven into a porous, cavernous siliceous mass, evidently representing a place of more intense alteration of the

rhyolite. A number of open cuts and shallow shafts have been excavated at other points, but no extensive bodies of quicksilver ore have so far been found.

Mammoth No. 5 claim.—The Mammoth No. 5, owned by J. F. Grant and associates, is situated on another belt of silicified rhyolite, which lies somewhat west of the Mammoth group of the Telluride Consolidated Co. It is said to be traceable for more than 1,000 feet, but has been prospected only by a few shallow open cuts. The ore masses consist of a soft white material—hydrous silica mixed with opal and alunite—carrying finely disseminated cinnabar. This is traversed by irregular veins and masses of white opal and chalcedony. The ore material at the main prospect trench is the product of the transformation of porphyritic obsidian by siliceous cinnabar-bearing solutions.

In places along the belt of silicified rhyolite outcrops of chalcedony and opal as much as 50 feet wide appear. Although the best ore so far found occurs in the soft, pulverulent material, some cinnabar is locally inclosed in the hard siliceous reefs.

RELATION OF THE CINNABAR DEPOSITS TO THOSE OF THE QUICKSILVER BELT OF WESTERN NEVADA.

The existence of a quicksilver-bearing belt in western Nevada, in Humboldt, Esmeralda, and Nye counties, has long been recognized. The information concerning the cinnabar deposits of this belt has recently been assembled by McCaskey,[1] who contributes also a description of the ore bodies at Ione, in Nye County, the locality from which the principal production has so far been derived. The deposits east of Beatty described in the present report extend the quicksilver belt considerably farther south.

The general tendency of those who have described the deposits of this belt has been to regard them as genetically connected with the Tertiary and Quaternary volcanism of the province. The phenomena observable at Steamboat Springs support this conjecture. The hot waters issuing from these springs deposit a siliceous sinter which contains cinnabar and amorphous red antimony sulphide, together with lesser quantities of other metallic sulphides. According to Becker[2] the deposits have formed close to the edge of a basalt flow and probably result from the volcanic action of which the lava eruption was one manifestation. He believes that the water issuing from the springs comes from the Sierra Nevada; that it descends to great depths, where it becomes heated by contact with subterranean masses of hot basalt, and ascends along the fissures by which the lava

[1] McCaskey, H. D., Quicksilver: U. S. Geol. Survey Mineral Resources, 1911, pt. 1, pp. 906–909, 1912.

[2] Becker, G. F., Geology of the quicksilver deposits of the Pacific slope: U. S. Geol. Survey Mon. 13, pp. 338–350, 1888.

reached the surface. Concerning the genesis of the other quicksilver deposits of the western Nevada belt, opinions have been less precisely formulated, although, as already mentioned, these deposits also are regarded as of "volcanic origin," but probably this term is now used in a sense different from that which Becker had in mind.

It is difficult, however, to show that some of the deposits are related to the Tertiary volcanism of the province. Ransome,[1] in fact, is inclined to regard the quicksilver deposits of the Humboldt Range as of early Cretaceous age. The same difficulty inheres in any attempt to connect the cinnabar deposits east of Mina with Tertiary eruptive activity. On the other hand, it is interesting to note that a quicksilver deposit, clearly of Tertiary age, occurs in the volcanic rocks at Goldfield, which is midway between Mina and Beatty.[2] The deposits near Beatty are rather obviously associated with the Tertiary volcanism of that region. This association raises an important problem, for in the Bullfrog district, a few miles west of Beatty, the gold deposits, according to Ransome,[3] are genetically connected with this same general outburst of volcanism, though it was not found possible to link the ore deposition with any particular one of the many magmas that solidified as the lavas now exposed in the district. Among the most noteworthy facts shown by the study of the district is the remarkably feeble chemical alteration of the wall rocks of the ore bodies; and it was therefore concluded that the vein-forming solutions were dilute, cool, and under no heavy pressure. Now the notable feature of the quicksilver deposits in the rhyolites east of Beatty is the intense alteration of the rocks—their complete silicification and alunitization in belts hundreds of yards long and as much as 200 feet wide. This profound alteration points to the conclusion that the quicksilver-bearing solutions were under physical and chemical conditions quite different from those that prevailed during the deposition of the auriferous ores. From these considerations and from others arising from a review of the literature of the subject it appears that the genetic relation of the cinnabar deposits to the many gold deposits scattered through the western Nevada quicksilver belt constitutes an interesting problem for future research.

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[1] Ransome, F. L., Notes on some mining districts in Humboldt County, Nev.: U. S. Geol. Survey Bull. 414, pp. 46, 71, 1909.

[2] Ransome, F. L., Geology and ore deposits of Goldfield, Nev.: U. S. Geol. Survey Prof. Paper 66, p. 113, 1909.

[3] Ransome, F. L., Geology and ore deposits of the Bullfrog district, Nevada: U. S. Geol. Survey Bull. 407, p. 103, 1910.